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BOOK REVIEW

Contribution to the Sustainability and Equity Dialogue

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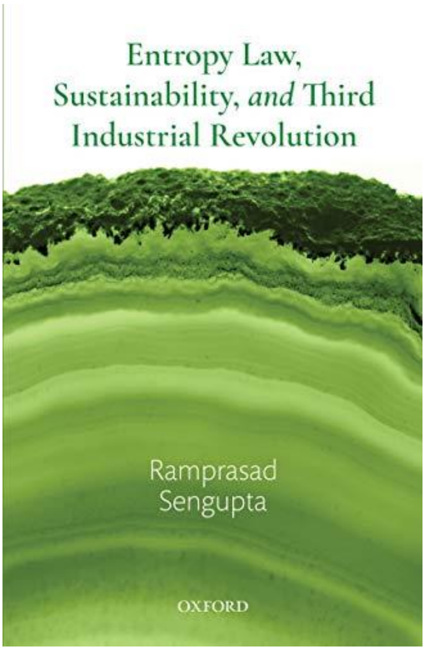
Ramprasad Sengupta, *Entropy Law, Sustainability, and Third Industrial Revolution*, Oxford University Press, New Delhi, 2020, pp. 271, ISBN: 9780-19-012114-3.



Two decades after Rachel Carsen's book, *Silent Spring,* woke up the world in the 1960s to the horrors of environmental pollution, there was widespread disquiet on another question—"Is the current global development trajectory sustainable?" To throw light on this question, the United Nations Secretary-General, Javier Pérez de Cuéllar, appointed the World Commission on Environment and Development, under the chairmanship of the former Norwegian prime minister, Gro Harlem Brundtland. The Brundtland Commission's definition of sustainable development, "development that meets the needs of the present without compromising the ability of future

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generations to meet their own needs," has since gained prevalence over other definitions (WCED 1987, 41).

But without the use of a quantitative index to measure progress towards sustainable development, qualitative definitions like the one above—notwithstanding their eloquence—may be used till the cows come home, but will remain sterile and unactionable. In the three and a half decades since the Brundtland Commission's definition came into vogue, the increasingly rapid pace of unsustainable development of human society has brought us to the verge of three tipping points—climate change, peak oil (represents the exhaustion of critical nonrenewal minerals), and growing inequality between and within countries. Each of these crises may independently cause the regression or even the collapse of human society, as has happened in some past civilizations.

SALIENT FEATURES OF PART 1 OF THE BOOK

The book *Entropy Law* offers a quantitative index to measure sustainable development in the form of the Overall Sustainability Development Index (OSDI). The author believes that all three dimensions of sustainability—economic, social, and environmental—are equally important. He elaborates on them as follows:

- Economic sustainability requires cost-effective growth to reduce poverty and inequality and helps abate violence. A positive indicator of economic sustainability is the growth rate, and negative ones are unemployment, inflation, the fiscal deficit, and indebtedness.
- Social sustainability requires equitable distribution of resources and social products. This will alleviate poverty, inequality, and deprivation, which in turn will reduce crime and social tension and give an impetus to social inclusion, gainful employment for all, and people's participation in governance.
- Ecological sustainability requires the reduction of the ecological footprint, improvement of environmental protection through resource conservation and pollution control, including CO_2, and avoiding ecological collapse.

Economic sustainability is quantified using the Inequity-adjusted Per Capita Income Index (Inequity-adjusted pc II); social sustainability using the non-income component of the Human Development Index (non-income HDI); and environmental sustainability using the arithmetic mean of the Ecological Footprint Index (EFI) and Environmental Performance Index (EPI). The OSDI is identified by computing the unweighted geometric mean of the indices for economic, social, and environmental sustainability.

A Social Sustainability Index (SSI) consisting of non-income HDI, EFI, and EPI has also been computed.

The book observes that the OSDI for various countries has a high correlation with the Inequity-adjusted pc II and SSI, indicating that economic growth is the main driver of human development and that environmental conservation requires public financing. The conclusions drawn are as follows:

a) Growth of national income and its stability are necessary for sustainable development

b) Social spending is needed to eliminate deprivation and create universal social access to the benefits of growth for people

The HDI and OSDI ranks of countries have a high correlation, indicating that the OSDI-computing methodology may be biased in favour of economic indicators.

SALIENT FEATURES OF PART 2 OF THE BOOK

This section discusses India's energy status and transition pathway from fossil fuels to green energies. The abundance of coal reserves in India has led to its dominance of India's energy basket along with oil. The share of fossil fuels in India's energy mix is 72%. India has little oil and gas and hence imports about 34% of its energy. Renewables, combustible biomass, and waste contribute 25% to the country's energy consumption. India's high GDP growth rate in recent decades has propelled energy consumption to grow at 4.1% pa between 1990–2013.

India's per capita energy use and CO_2 emissions are about one-third of the global average and one-tenth that of the USA. Access to electricity and clean cooking energy is low, particularly in rural areas. Yet, India's energy and carbon intensities (per unit GDP) are lower than the global average.

The abundance of biomass, solar, and wind (in some states) energy sources in India will allow green energies to replace fossil fuels and usher in the Third Industrial Revolution. Hydro and nuclear energy are green energy candidates but will not make the cut. Hydro's declining share in India's energy basket is due to long project gestation periods, human displacement, and adverse environmental impacts. Nuclear energy capacity will grow significantly only if India succeeds in mastering fast breeder reactor technologies, for which India has fuel in abundance. Further, hydro and nuclear energy projects face resistance from people.

The results of a demand model, which projects electricity requirements in the future in various assumed scenarios, indicate that the generation capacity of all types of fuels will grow, though renewables will grow at a faster rate than fossil fuels. It is possible to significantly delink emissions from growth. To set up large solar and wind capacities, adequate financing and trained manpower are required. The expansion of renewables will reduce energy poverty, create energy security, and reduce the carbon footprint.

The book concludes by stating that strategies for economic growth must be combined with investments for social and environmental infrastructure development. Environmental sustainability requires that the ecological footprint be reduced and that steps are taken to protect the environment. The reduction of poverty and inequality will promote economic growth and human development. However, capitalist economies are designed for market development, which runs counter to controlling entropy increase.

DIALOGUE

Entropy Law has done a creditable job in developing a much-needed quantitative index—OSDI—and discussing the future of the Indian energy sector in light of sustainability and equity issues. Rather than view this section as a book review, it must be viewed as a continuation of the dialogue on sustainability and equity, to which *Entropy Law* has made a valuable contribution.

Is OSDI the best indicator? In the last decades, several development indicators that prioritize diverse values have been proposed. For example, the Gross National Happiness Index (United Nations n.d.) measures the happiness and well-being of a country's population. The Genuine Progress Indicator separates societal progress from economic growth (CSE n.d.). The environmental HDI (eHDI) foregrounds the principles of equity, historic responsibility, and planetary boundaries by internalizing the climate and ecological pressures of economic growth. In complete contrast to their HDI and OSDI ranks, Panama, Costa Rica, and Sri Lanka have high eHDI ranks, whereas the USA, UK, and Singapore rank low (Bhar and Dhara 2021).

OSDI does not consider historic responsibility for territorial or consumptive emissions or the extraction of surplus by developed nations through unequal exchange with underdeveloped regions. These factors are important for climate and economic justice. By internalizing the EFI and EPI, the OSDI at best indirectly covers the extent of infringement of planetary boundaries, an important factor for understanding sustainability. OSDI also does not cover the happiness of the population. Had *Entropy Law* argued its eminence vis-a-vis a dozen-odd 'holistic' indicators, it may have gained more attention.

Is Entropy Law's discussion on sustainability adequate? While *Entropy Law* glancingly warns of the upper limit of our planetary ecosystem's capacity to meet human demands, it repeatedly stresses the need for economic growth in India for poverty and inequality reduction. A discerning reader would then ask, what are the planetary limits to growth? How much can India grow? Is the growth of the Indian economy contingent on the degrowth of Global North countries; how is this politically feasible?

Sustainability has two aspects to it, i.e., the earth has finite resources and a finite capacity to process wastes. Both aspects are discussed briefly below. There have been a series of warnings since the 1950s that the earth's resources are finite, but these have been ignored. Based on oil reserves and production data, King Hubbert predicted in 1956 that oil production in the US would peak by the 1970s and subsequently decline. His theory came to be known as 'peak oil' and was subsequently applied to global oil, coal, gas, and other non-renewable minerals. Peak oil occurred about two years ago, and oil reserves will be exhausted in another 40–50 years. Likewise, gas will be exhausted in about 60 years, and coal, before the end of this century (Ghosh and Perlas 2009).

The first report of the Club of Rome took the world by storm in 1972 when it raised the question of the earth having a finite capacity to provide resources and absorb wastes (Club of Rome 1972). Sequels to this report have deepened our understanding of this issue.

About 80 non-renewable minerals, including iron and copper, are expected to deplete to critical levels by 2100 because of their high rate of extraction. In his book *Blip,* Christopher Clugston refers to this as "Humanity's 300-year self-terminating experiment with industrialism" (Clugston 2019).

Likewise, that global warming is caused by human emissions has been known since 1896, when Arrhenius published his first calculation. Yet, it took more than a century for the world to wake up to this reality.

"Keep 1.5^{o}C alive," i.e., that global warming must be restricted to 1.5^{o}C, was the mantra that was chanted repeatedly in the COP 26 held in November 2021 in Glasgow. In its report published in 2021, *Climate Change 2021: The Physical Science Basis*, the IPCC warns that to meet the ≤1.5^{0}C ambition, current emissions must be halved by 2030–35, and the world needs to become net carbon zero by 2050–55 (IPCC 2021). To meet those targets, emissions must reduce by 7% pa for the next 30 years. However, emissions have grown by 1.2% pa since the 2015 Paris Agreement was signed (Ritchie, Roser, and Rosado 2020a).

The difference between expected emissions in 2030 (based on current performance and country pledges to tackle climate change), and desirable emissions in 2030 to be ≤ 1.5°C compliant, known as the emissions gap, has doubled between the assessments made by the UNEP in its 2016 and 2020 *Emissions Gap* reports (UNEP 2016; UNEP 2020). Efforts made so far to curb emissions have failed.

There are then good reasons to believe that keeping 1.5°C alive is an unviable ambition (Dhara 2022). For instance:

- Global warming due to greenhouse gases has already hit 1.5°C but has been temporarily muted by particulate matter air pollution.
- The top six greenhouse gas (GHG) emitters, who together contribute 70% of global emissions, have shown inadequate ambition to reduce their emissions.
- Shifting climate targets, and climate science and policy being at odds, have not created an atmosphere conducive to emissions reduction.
- A quarter-century of demand-side management to reduce fossil fuel use has failed.

Our current emissions control trajectory, provided all country pledges are fulfilled, will result in a warming of 2–3°C by 2100. This warming is unacceptable as it will catastrophically impact the global environment and human society.

Renewable energy consumption has trebled in India since the 1997 Kyoto Protocol was signed—as has that of fossil fuels (Table 1)—in a Jevons Paradox-like situation. Instead of replacing fossil fuels, renewable energy is supplementing them. This is a global phenomenon (Table 1). *Entropy Law* does not mention this phenomenon while discussing the question of sustainability.

Table 1: Global and Indian Energy Use by Type Since the Kyoto Protocol Agreement

	World		**India**	
	Fossil fuels (Gtoe)	Renewable energy (Gtoe)	Fossil fuels (Gtoe)	Renewable energy (Gtoe)
1997	7,740	670	259	19
2019	11,760	1,600	733	63

Source: Ritchie, Roser and Rosado (2020b).

Without considering the above aspects, how good are *Entropy Law's* projections regarding India's future electricity demand and how to meet it? Must some other countries reduce their fossil fuel consumption to allow India to meet its poverty alleviation targets?

Is sustainability in one country possible along with climate justice? *Entropy Law* has touched on the divide between the Global North and South nations on fossil fuel use. To protect their development standards, North nations wish to restrict emissions to avoid a temperature rise of more than 1.5–2°C. South nations that have been experiencing high growth rates (e.g., China and India) in the last three to four decades, have prioritized national development by consuming more fossil fuels over curbing emissions—despite knowing that they are among the most climate-vulnerable regions with populations that have low resilience. Since the 2009 Copenhagen COP, differing objectives for national development and consequently dissonance in the understanding of emissions control has been at the root of conflict between North nations and high growth South nations with large emissions.

There are only two solutions to this impasse. One, that the world comes together as one people to tackle climate change, agreeing to share equitably the wealth and risks that fossil fuels have produced, which is what climate justice truly is. Second, the North nations impose their will on the South and curb global fossil fuels consumption without providing the South with the means to eradicate poverty and inequality, which is not climate justice.

At the time of writing this review, two weeks into the Ukraine war, the world is experiencing a serious oil shock, unseen since 1980. A 5% reduction in oil supplies has doubled oil prices in just the last two months to nearly $140/bbl, which will cause a global inflationary trend. The unfolding scene gives us a glimpse into a bleak resource-scarce future in an inter-connected world.

By stating that poverty and inequality alleviation is necessary, but by discussing sustainability only in the Indian context, is *Entropy Law* stating that sustainability and climate justice in one country is possible? If so, the book should have argued its case.

***Energy statistics may be deceptive*: ** *Entropy Law* states that the potential green power generation capacity is estimated to be 3,400 GW, of which solar, wind, and other new renewables constitute 95%. While this may appear to be a large capacity, only a fraction of it will deliver power.

Intermittence of solar and wind power: Solar and wind energy have low power load factors (plf) due to intermittence. Though renewables other than hydro constituted 27% of the power generating capacity in 2020, they generated only 9% of the power (Table 2).

Table 2: India's Power Generating Capacity and Power Generated in 2019–20

	Total power generation capacity/power generated	Fossil fuels (%)	Hydro (%)	Wind, solar, other renewables (%)	Nuclear (%)
Power generation capacity 31 Mar 2020[1]	446 GW	60	12	27	4
Power generated 2019–20	1,383 TWh	79	10	9	2

Source: CEA (2021)

Technology deployability: Mean theoretical global wind energy is estimated to be 1,200 TW, but the deployable amount is only 1 TW due to difficulties in reaching or servicing areas that have high wind potential, the fraction of wind potential available in the lowest layer of the troposphere, the fraction of wind that interacts with the generator's blades, and energy conversion efficiency. It is not clear whether the power generation capacity figure of 3,400 GW quoted in *Entropy Law* refers to the theoretical potential or deployable energy.

Depletion of critical non-renewable substances used in renewables: Many non-renewable substances whose reserves will deplete dangerously within this century are used in wind and solar energy technologies. For example, a large amount of copper is used in electrical grids, motors, wind, and solar technologies. About 2.7 and 8–15 T/MW of copper is used in onshore and offshore wind generators, respectively. By 2030, about 40% of copper production is projected to be used by the renewable energy sector. Given current known reserves, copper will be exhausted in about 40 years (Capilla and Delgado 2014). Only about 40% of used copper is recycled. This implies that copper prices will shoot up to that of silver in another decade.

The permanent magnets in wind turbines are made of neodymium-iron-boron and dysprosium. The European Union has put neodymium and

[1] There is a rounding off error of 1% in the total of the percentage breakup of power generation capacity.

dysprosium on a high-risk supply list and the US Department of Energy identifies dysprosium as a most critical substance that may be in short supply in the short and medium terms (Capilla and Delgado 2014).

Has *Entropy Law* considered the low plf's of renewable energy, the deployability of renewable energy technologies, and material shortages while quoting green power capacities?

Entropy and sustainability: *Entropy Law* refers to entropy and the Second Law of Thermodynamics (the book refers to it as the Entropy Law). Except for making a few terse statements about entropy, the book does not connect entropy to its main arguments. The book would have read better had no reference been made to entropy.

CONCLUSION

If we desire a sustainable, equitable, and peaceful society, the above dialogue leaves us with these questions:

- How much of nature (energy and matter) can human society use to call itself a sustainable society? If that quantity is significantly less than today's extraction, should degrowth be an option that should be contemplated seriously, particularly considering peak oil and climate change?
- Why did we go into overshoot? What will keep us from repeating that mistake?
- What are the principles and mechanisms for production, distribution, and ownership of goods, services, and surplus created from nature?
- Where will energy and material be sourced from in the future?
- Why is direct sunlight, the energy that is most suitable for a sustainable society, never valued? How should the valuation of goods and services be carried out in a sustainable and equitable society?

Entropy Law has done its job by developing an index to quantify sustainability and showing how India's energy sector can move towards renewable energy. It is for us to now carry the discussion forward.

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